

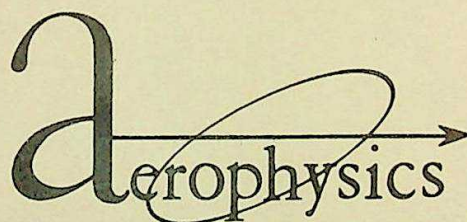
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FANS, BLOWERS, AIR CONDITIONERS AND NOISE

A BIBLIOGRAPHY

AEROPHYSICS COMPANY REPORT AR74-661

Date → October 1974



AEROPHYSICS COMPANY

Washington, D.C.

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ABSTRACT

A bibliography is presented of available literature on the topics related to fans, blowers, air conditioners and noise, and most important their inter-relationships. This search attempts to cover the international literature and includes the Library of Congress, NTIS, DDC and the patent art.

FOREWORD

The purpose of this bibliography is to provide a background and a source of information for a program to reduce the noise levels of the Vertical and Horizontal Families of Military Compact Air Conditioners and their installation in vans and shelters. The basic search was carried out during August and September of 1974. This work was done under contract DAAK02-74-C-0375 with Mr. Lawrence Folk as the Contracting Officer's Technical Representative.

The authors wish to gratefully thank the ever thorough and persistent Mrs. Winifred Luché for her final editorial control of this document. Much sympathy and grateful thanks are extended to Miss Dale Copeland for her relentless and diligent typing and general production of this bibliography.

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INTRODUCTION

Background

Fans and blowers and the equipment they are usually installed in are often noisy. In the past, customer and user acceptance of such equipment had little concern with the problem of noise. However, present day standards require that equipment exhibit reduced noise characteristics. The source of noise in these situations is either aerodynamic in nature or mechanical in origin. The control of this noise, is often as not, an art. Many researchers and workers in unrelated fields have singularly attacked the noise reduction problem rather much in an unco-operative or rather non-co-operative manner, and often in a vacuum. That is to say, there appears to be no accumulation of the art and diverse groups such as heating and ventilating specialists, aircraft engineers and researchers, seldom, if ever, cross communicate or exchange ideas. Their studies and findings, if published at all, often appear in specialized journals, obscure reports and in foreign language publications.

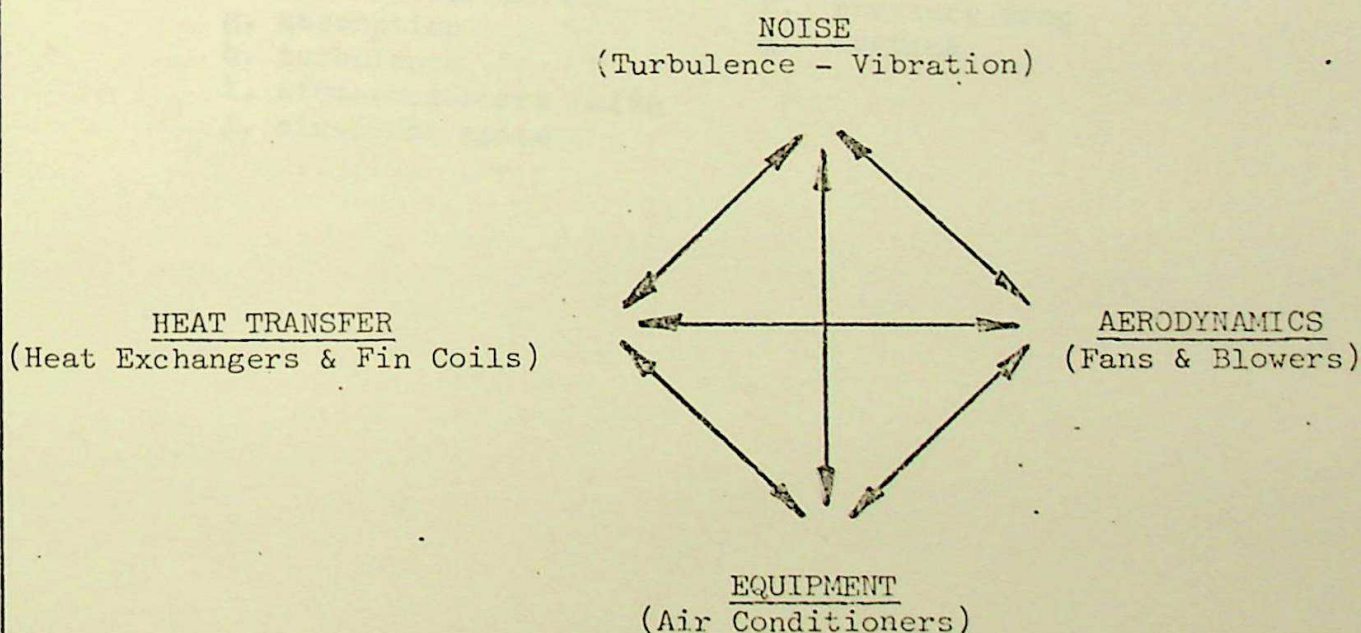
Presented here for the first time is a preliminary bibliography on what we found to be the state of the art of noise as it relates to air moving machinery in general and air conditioners in particular. The resulting literature search and this preliminary bibliography, although certainly incomplete at this time, is the first attempt we know of to identify and categorize interrelated topics concerned with the problem of air moving noise.

The material collected was first put together in earnest several years ago when the Aerophysics Company initiated the study to redesign the condenser fans of the U.S. Army's Vertical Family of Compact Air Conditioners. The need to update the collection came from the present product improvement program requiring greater organizational and literature retrieval efforts in order to keep this project current. By current, we feel that an initial review of the technical literature in depth would be in order so that we may truly come to understand the details of the problems we will be facing. Practically, the identification and accumulation of this wealth of material is necessary in that the literature suggests, and often positively identifies, means to solve the products improvement and noise problems which occur.

Topics Covered

The central core of this bibliography is the relationship of noise to air moving or air conditioning equipment. The noise may be aerodynamic in origin and usually has its source at the fans and blowers in the form of aerodynamic turbulence carried to the ear of a listener. Mechanical noise usually has its source in the vibration of mechanical sources and is transmitted through the structure eventually into the air and to the ear of the listener. Particular emphasis in this bibliography is concerned with the noise generated by fans and blowers, and the aerodynamic and design characteristics of these fans and blowers. In the air conditioning equipment the primary influence on the aerodynamics of the fans is the duty point at which they must operate. This duty point in turn is determined by the internal air flow requirements and resistance of the units. The main source of resistance in air conditioning units, of course, are the heat transfer or fin coil elements. Other secondary elements, such as grilles, louvers, filters and screens, also offer a source of resistance to the air flow and in addition to increasing the fan noise, are themselves also sources of noise. Thus, one cannot survey the art of equipment noise reduction without examining in some detail the aerodynamics, performance and design of fans. In the same manner, one must also investigate in a detailed manner the characteristics of fin coils and other air passage elements.

FIELD OF COMBINED TOPIC INTEREST



The sketch shows diagrammatically the relationship between the four topics of noise, heat transfer, aerodynamics and equipment. This is essentially a diagram which directed the interest of the literature search staff as they went about collecting and identifying literature. In essence, this diagram puts a boundary around the problem area of subject and reflects the combinations of topics which are of central interest to the noise reduction project. Thus, the bibliography will identify sources of information which also have their interest in combinations of the topics shown in the diagram. For example, there are references cited which describe the problems of noise and vibration in equipment which contain blowers; or taking another direction about the diagram, there are references concerned with the aerodynamics of fans operating in conjunction with heat transfer or fin coil elements. This diagram may serve the searcher or reviewer as a guide to the rough contents of what follows in the bibliography.

To further reduce these topics of bibliographical interest, the following descriptor-like listings are presented here to define the scope of each of the topics diagrammed.

Noise

- a. vibration
- b. balance
- c. attenuation
- d. muffling
- e. equipment
- f. sound power levels
- g. absorption
- h. turbulence
- i. structure-borne noise
- j. air-borne noise

Heat Transfer

- a. air conditioning
- b. air conditioners
- c. fin coils
- d. heat exchangers
- e. flow resistance
- f. pressure drop
- g. testing

Aerodynamics

- a. fans
- b. centrifugal fans
- c. axial fans
- d. cross flow fans
- e. mixed flow fans
- f. inlets
- g. outlets
- h. screens
- i. filters
- j. grilles
- k. louvers
- l. baffles
- m. enclosures
- n. flow resistance

Equipment

- a. air conditioners
- b. fin coils
- c. heat exchangers
- d. electric motors
- e. fan wheels
- f. sound reducing materials
- g. military units
- h. compressors
- i. grilles and louvers
- j. screens
- k. bearings

It is important to realize that this bibliography only collects and organizes those references in which there are combinations of topics as we have described above. One exception, however, is in the coverage on aerodynamics and design of fans. It is felt that the references to fans may stand alone as a singular topic; and, as such, present for the first time a unique collection and collation of the fan literature.

As we have discussed the topics that are covered, it is wise to also describe to the reader those topics which do not appear in the bibliography. For example, when we talk about fans and fan aerodynamics and design, we do not consider those systems of moderate and high pressure ratio as one might find in blower systems or compressors. There is no inclusion, for example, of the extensive literature on axial compressors. The tip speeds of the fan wheels in the included literature is on the low side, covering the subsonic regime and seldom considering fan wheels with a tip speed greater than 250 feet per second. Similarly, aircraft type propellers for propulsion, and lift fan systems as applied to air cushion vehicles and the like are not included. Discussions of air flow in ducts and bends as isolated elements are not discussed. Discussion of duct mufflers and attenuators is not given much specific attention. Diffusers, such as those that convert velocity to pressure, are not identified in this search. A definitive bibliography on this type of diffusers is available from another source. This type of diffuser should not be confused with the heating and ventilating type diffuser which is concerned with the air distribution or outlet flow into a room, which is included.

Scope of the Search

In preparing this bibliography a research team hand searched the technical collection of the Library of Congress and The U.S. Patent Office, both located in Washington, D. C. The government reports held by DDC and NTIS were identified by the use of their abstracts and indexes, and through computer bibliographical searches.

The patent art referenced in this bibliography is highly selective to avoid overburdening the bibliography with material not of direct use. The patents cited here are deemed to be especially pertinent to immediate problems which we have or feel that we may encounter in the air conditioner noise reduction project. The patent art identified here usually describes interesting techniques in noise reduction as applied to equipment and air moving systems. Much of this material is now in the public domain. One is cautioned, however, that the patent material attaches no quantitative value to the statements made by the inventor and is included here to stimulate ideas.

The foreign literature was reviewed by Dr. Soukhanov, an engineer fluent in Russian, German and French. Foreign titles have been translated whenever possible for the convenience of the user.

Use and Retrieval

The citations in the bibliography have been made as complete and consistent as possible. It will be noticed that the Library of Congress call number is given with each citation wherever possible. Those items which appear in the NTIS or DDC collections are identified with the accession number wherever possible. Patents are easily retrieved by their number and may be purchased directly from the U.S. Patent Office.

Addendum

As this literature collection moved forward and into final editing, arrangement and typing, quite naturally much other information and citations came to light. It was, however, necessary to freeze the collection at some point. The reader will undoubtedly be aware of several references of importance which may have been overlooked. Given time and funding it would be very desirable to make an addenda at a later date to update this collection. Readers are kindly requested to send any references or citations for inclusion into any updating of this bibliography.

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